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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF CHEMISTRY—BULLETIN NO. 82.

H. W. WILEY, CHIEF OF BUREAU.

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PARIS GREEN SPRAYING EXPERIMENTS.

BY

ohn erfoot

J. K. HAYWOOD,

Chief Insecticide and Agricultural Water Laboratory,

In collaboration with the Division of Entomology, U. S. Department of Agriculture, and
the agricultural experiment stations of Maryland, New York,
New Hampshire, Rhode Island, South
Carolina, and Oregon.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., March 19, 1904.

Sir: I have the honor to transmit for your approval a report on a series of spraying experiments with Paris Green, prepared in the insecticide and agricultural water laboratory of this Bureau, and to recommend its publication as Bulletin No. 82 of the Bureau of Chemistry. It is desired to acknowledge especially the cooperation of the Division of Entomology and the contributions of the various experiment stations named, at which so large a part of the work was performed. The two half-tone plates express graphically one of the most important points made in the bulletin and are deemed of value in impressing the conclusions drawn in the text.

Respectfully,

H. W. Wiley, *Chief.*

Hon. James Wilson,
Secretary of Agriculture.

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PARIS GREEN SPRAYING EXPERIMENTS.

REASONS FOR THE INVESTIGATION.

These experiments were undertaken to show how much soluble arsenious oxid may be present in samples of Paris Green used for spraying purposes without injury to the foliage. As is well known, Paris Green is composed of copper oxid, acetic acid, and arsenious oxid, combined as copper-aceto-arsenite in the following proportions:

	Per cent.
Copper oxid	31.29
Arsenious oxid	58.65
Acetic acid	10.06

Since this substance is always sold upon the market as a commercial rather than a chemically pure article, small amounts of impurities are always present. Among these may be mentioned sand, sodium sulphate, and arsenious oxid, the last of which is not combined as it should be with the other constituents, but is present in the free state. It is to this impurity of Paris Green that the scorching properties are usually ascribed. California has passed a law limiting the amount of free arsenious oxid in Paris Green to 4 per cent, while New York's law limits the amount to 3.5 per cent. In the other States, where there are no laws governing the matter, the entomologists usually consider 4 per cent of free arsenious oxid to be the maximum amount allowable in Paris Green used for spraying.

It does not seem to have been generally recognized by entomologists[a] and chemists that there may be three conditions of Paris Green which will cause a scorching of the foliage.

(1) As indicated above, there may be a certain amount of arsenious oxid in Paris Green over and above that combined with the other con-

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[a] Marlatt in two articles (Insect Life, vol. vii, July, 1895, pp. 408–411, and bulletin No. 6, Division of Entomology, September, 1896, pp. 30–35) has recognized the first and third conditions of Paris Green that may give rise to a scorching of the foliage, but not the second condition.

stituents. This is "free" arsenious oxid and until recently it has been considered the only cause of a scorching of the foliage by Paris Green.

(2) The greens may be poorly made so that the constituents are very loosely held together. When such greens are brought in contact with water, especially water containing carbon dioxid, they are soon broken up and arsenious oxid is set free. Even the best greens break up to some extent under such conditions, but the poorly made greens decompose much more rapidly. Note, then, the effect of such greens upon the foliage. First, the water of the spray would act at once on the green and set arsenious oxid free, then carbon dioxid would dissolve in the water and carry the decomposition of the green still further. But the matter would not end here, for the rain and dew both containing carbon dioxid would also act upon the green and enough free arsenious oxid would soon collect to severely scorch the foliage. This would of course take place more slowly with even the best greens, but unless the climatic conditions were very adverse, not enough free arsenious oxid would be apt to accumulate at one time to cause any serious damage.

(3) The green may be extremely fine. It is well known that even the best greens when ground to a very fine powder and applied to the foliage will scorch. This is doubtless due to the fact that more surface is exposed to the action of water, which may contain carbon dioxid, so that its decomposing action on the green is accelerated and enough free arsenious oxid soon gathers to cause serious damage. Avery and Beans[a] found that the very best Paris Greens obtainable were slowly attacked by water, and by grinding the same greens to a very fine powder and suspending them in water the rate of decomposition was enormously increased. They also found that carbon dioxid in the water increases the rapidity of decomposition.

It is a very common occurrence to secure a commercial Paris Green that scalds because of one of the first two causes—i. e., either by reason of the presence of free arsenious oxid or because it is poorly manufactured—but the writer has never found a commercial sample of green that scorched because it was in too fine a condition. In experimenting on the third method of scorching even the finest samples of green found on the market had to be ground further before they would scorch by reason of minute division.

It is thus seen that the chemist will be called upon to examine samples of green (1) for actual free arsenious oxid; (2) for arsenious oxid that may be easily set free on account of the instability of the compound. Methods of determining these two forms of soluble arsenious oxid have been devised during the last few years which, though not strictly accurate, will give results close enough for all practical purposes. These methods, with the reason for their adoption, are as follows:

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[a] J. Amer. Chem. Soc., 23: 111.

In determining soluble arsenic it is evident that it would not be sufficient to extract the green for only 24 hours with water, since in samples containing free arsenious acid as such, all of the arsenic does not go into solution in that length of time, and neither do samples that are poorly made break up to any extent within twenty-four hours. The author has found that it takes from five to ten days, according to the amount present, for all the free arsenious oxid to go into solution. It has also been found that badly made greens are broken up enough during the course of ten days to give some idea of their instability and that well-made greens are not broken up to any great extent during that length of time. It has therefore been thought best to determine the soluble arsenious oxid in Paris Greens by extracting one part of the green with 1,000 parts of carbon dioxid-free water for ten days and at the end of this time determining the arsenious oxid in an aliquot portion of the filtrate. This method shows whether the green contains a large quantity of free arsenious oxid or whether it is badly made, but does not distinguish between the two. A method devised by Avery and Beans,[a] however, allows us to approximately determine the amount of free arsenious oxid present exclusive of that formed by the decomposition of the green. Therefore, by using both methods the chemist will be able to tell either the amount of free arsenious oxid actually present in the green or the amount that is apt to be present a short time after spraying. Both of these forms of soluble arsenious oxid are undoubtedly injurious, although perhaps not equally so.

These two distinct types of soluble arsenious oxid in commercial Paris Green have not been previously recognized, and furthermore when 4 per cent was adopted as the maximum amount of soluble arsenious oxid allowable in Paris Green the extraction with water was continued for a much shorter time, resulting in much lower figures for soluble arsenious oxid. It would appear, therefore, that investigation along this line is needed[b] to determine the maximum amount of soluble arsenious oxid, as found by our present methods of analysis, that can be present in a Paris Green in both forms without danger of scorching. This investigation is an attempt to answer the question under the first condition, i. e., when the soluble arsenious oxid is present in the free condition. It is hoped that in the near future experiments may be made on Paris Greens of the second type.

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[a] J. Amer. Chem. Soc., 23: 111.

[b] Valuable work upon the effect of arsenic and arsenite on plants has been published by Gillette, Woodworth, Bailey, Marlatt, and others, but not along the lines followed in this experiment.

PRELIMINARY WORK AT WASHINGTON, D. C.

PLAN OF THE EXPERIMENT.

Preliminary work was begun during the early summer of 1902, and carried out in the following manner: A large quantity of Paris Green, as pure as could be obtained, was purchased and a determination made of the soluble arsenious oxid by the ten-day water-extraction method. Then known quantities of perfectly pure arsenious oxid were added to different quantities of the green, so that samples of a definite arsenious oxid content were obtained. Each of these samples contained to 1 pound of Paris Green the following amounts of soluble arsenious oxid:

	Per cent.
No. 1	4.29
No. 2	5.00
No. 3	6.00
No. 4	7.00
No. 5	8.00

Two sets of these samples were made up and applied in the following manner:

SET I.

Treat one-half of each of 5 samples described above with 150 gallons of water, making 1 pound to 300 gallons, and spray delicate trees, such as peach trees.

Treat the other half of each of the 5 samples with 150 gallons of water, making 1 pound to 300 gallons, and 1 pound of lime, and again spray delicate trees, such as peach trees.

SET II.

Treat one-half of each of above 5 samples with 80 gallons of water, making 1 pound to 160 gallons, and spray hardy trees, such as apple trees.

Treat the other half of the 5 samples with 80 gallons of water, making 1 pound to 160 gallons, and 1 pound of lime, and again spray hardy trees, such as apple trees.

The dates of spraying and taking of observations and the duration of the experiment were carefully noted.

With the aid of Mr. F. C. Pratt, an assistant in the Division of Entomology, the author sprayed young peach, apple, and pear trees, following very closely the directions outlined above. The trees grew in the Agricultural Department grounds, and, unfortunately, had been used before in various experiments upon insects and sprays, so that all of them were not in a perfectly healthy condition. Since they were the only trees available, and the investigation was only preliminary in character, to fix within wide limits the amount of soluble arsenic that can be endured by the trees, it was thought they would serve the purpose. The table on the next page, giving the weather conditions during the first part of the experiment, is furnished by the United States Weather Bureau.

Weather conditions, Washington, D. C., June 20 to July 15, 1902.

Date.	Mean temperature.	Precipitation.	General character of day.
1902.	*° F.*	*Inches.*	
June 20	73	Trace.	Partly cloudy.
21	73	0.85	Cloudy.
22	64	.00	Clear.
23	64	Trace.	Partly cloudy.
24	60	.00	Do.
25	64	.01	Clear.
26	73	1.37	Do.
27	72	.00	Partly cloudy.
28	70	.01	Cloudy.
29	80	.03	Partly cloudy.
30	66	.31	Cloudy.
July 1	68	[a].01	Clear.
2	72	.00	Do.
3	82	.06	Partly cloudy.
4	80	Trace.	Do.
5	84	.00	Do.
6	84	Trace.	Do.
7	74	Trace.	Cloudy.
8	81	.00	Partly cloudy.
9	82	.00	Do.
10	78	.34	Do.
11	70	.00	Clear.
12	70	.00	Do.
13	72	.00	Do.
14	79	.00	Do.
15	82	.02	Do.

[a] In the morning, before the trees were sprayed.

OBSERVATIONS.

The trees were first sprayed on June 20. The next day a heavy rain fell, which seemed to wash off the Paris Green completely. After waiting for 10 days—i. e., until July 1—to see whether the trees would be affected, they were again sprayed, no damage being observed at that time. After the second spraying observations were made on the following dates: July 5, 10, 16, August 11, and September 18, 1902.

With the peaches the results were somewhat irregular on account of the varying hardiness of the trees and the fact that some of them were attacked later in the season by insect pests; but a few general conclusions can be drawn. As one would expect from previous experiments, the peaches did not show any injury from the spray until after the first considerable rain, on July 10. Then the trees on which lime was not used were all more or less burned and partly defoliated, except the one sprayed with solution No. 3 (6 per cent of arsenious oxid). This tree was very hardy and was not injured in any way. The tree sprayed with solution No. 1 (4.29 per cent of arsenious oxid), without lime, was not injured to a great extent, but a few leaves fell. The injury to trees when lime was used with the Paris Green was not nearly so great as when lime was not used, which was to be expected. Those sprayed with solutions Nos. 1, 2, and 3 (4.29, 5, and 6 per cent of arsenious oxid), with lime, while showing a slight yellowing, spotting, and falling of the leaves, were not injured to any great extent, and the falling of the leaves soon ceased. All of the sprayed peach trees lost their leaves much earlier in the autumn than is common in and around Washington; but as all of the trees near by had been used in the experiment it was not possible to make any comparison with unsprayed trees to ascertain whether the premature ripening of the leaves was due to some other cause than the poison.

The apple trees when sprayed with varying strengths of arsenious oxid, without lime, all showed about 1 to 2 per cent of injury. A few leaves were curled and burned at the edges where the Paris Green had collected in the greatest quantities, but the injury was slight, and after these leaves fell the trees did not show that they had been sprayed at all. All were in good condition and remained so throughout the summer, except the one sprayed with solution No. 1, which died during August.

The same results were obtained on the trees sprayed with the various solutions after the addition of lime. None was seriously injured, and in about two weeks after the spraying no effects could be seen. In the case of the tree sprayed with solution No. 2, with lime, it was observed that about one-third of the leaves had fallen on September 18, but as the trees sprayed with much stronger solutions were in no way affected it appeared that the dropping of the leaves was not caused by the spray. It was noted in the case of trees sprayed both with and without lime that about one-half of them lost the greater part of their leaves by October 12, which is rather early in this climate. This was not true to so great an extent of the trees that had been sprayed with the addition of lime, but still there was a tendency in this direction. Four extremely hardy apple trees, sprayed with solutions Nos. 3 and 4 (6 and 7 per cent arsenious oxid), with lime, did not drop their leaves early, while two trees, not so hardy, that were sprayed with solutions Nos. 1 and 2 (4.29 and 5 per cent arsenious oxid) dropped over one-half of their leaves by October 12. It did not appear that the premature dropping of the leaves in the autumn was accompanied by any permanent injury to the tree.

The pear trees, in those cases in which no lime was used, had a few leaves burned on the edges at the first and second observations, but these soon dropped off or withered away, and the trees were in excellent condition. In fact, it may be said that pear trees sprayed with any of the five solutions without lime were practically unaffected, none being damaged to the extent of 2 per cent. The trees sprayed with any one of the solutions with lime were not scorched in the slightest degree.

Toward the end of the season the tree treated with solution No. 1 (4.29 per cent of arsenious oxid), without lime, died, and the tree treated with solution No. 2 (5 per cent of arsenious oxid), with lime, dropped its foliage prematurely, but this was not attributed to the spray, since trees treated with much stronger solutions were in excellent condition, and, furthermore, the injured trees appeared to have been attacked by pear-leaf blight, so that a large number of leaves turned black and withered.

SUMMARY OF RESULTS.

Under the conditions prevailing during the early summer of 1902 at Washington, D. C., the following conclusions may be drawn:

(1) If lime is not used peach trees can not be sprayed with Paris Green containing even as little as 4.29 per cent of soluble arsenious oxid; if lime is used greens containing as much as 6 per cent of soluble arsenious oxid may be used without causing serious damage.

(2) Apple trees may be sprayed with Paris Green containing as much as 8 per cent of soluble arsenious oxid, either with or without lime, without any immediate injury to the tree, although what the effect might be in causing the trees to drop their leaves prematurely and expose the fruit has not been determined.

(3) Pear trees may be sprayed with Paris Green containing as much as 8 per cent of soluble arsenious oxid, either with or without lime, without any injury to the tree.

ORGANIZATION OF COOPERATIVE WORK.

During the spring of 1903 the author addressed a letter to the entomologists of several of the experiment stations in different parts of the country asking for their cooperation in a continuation of this work. Favorable replies were obtained from about ten different stations, but reports were received only from the following: John Craig and H. E. Weed, Ithaca, N. Y.; C. M. Weed and J. L. Randall, Durham, N. H.; F. W. Card and A. E. Stene, Kingston, R. I.; C. E. Chambliss, Clemson College, S. C.; and A. B. Cordley, Corvallis, Oreg. Since the fruit trees could not be obtained in Washington for spraying, permission was obtained of Director Patterson, of the Maryland Agricultural Experiment Station at College Park, to use trees upon the experimental farm. The spraying and taking of notes was done by Mr. Smith, of the Bureau of Chemistry, and Mr. Symons, of the Maryland station.

PREPARATION OF SAMPLES.

As in the previous year's work, a large keg of as fine Paris Green as it was possible to obtain was purchased and subjected to a chemical examination. It was found that 2.84 per cent of soluble arsenious oxid was present, according to the ten-day water-extraction method. Definite quantities of chemically pure arsenious oxid were added and four sets of 6 samples each of Paris Greens were obtained and sent to all the collaborators. Each sample weighed 1 ounce and contained the following amounts of soluble arsenious oxid:

	Per cent.
No. 1	2.84
No. 2	4.00
No. 3	5.00
No. 4	6.00
No. 5	7.00
No. 6	8.00

DIRECTIONS FOR SPRAYING.

(1) Treat each of the 6 samples with 9.5 gallons of water (approximately 1 pound to 150 gallons) and spray hardy trees such as apples and pears.

(2) Treat each of the 6 samples with 9.5 gallons of water and 2 ounces of previously slaked lime, and again spray hardy trees such as apples and pears.

(3) Treat each of the 6 samples with 15.5 gallons of water (approximately 1 pound to 250 gallons) and spray delicate trees such as peaches and plums.

(4) Treat each of the 6 samples with 15.5 gallons of water and 2 ounces of previously slaked lime, and again spray delicate trees such as peaches and plums.

Make duplicate and triplicate experiments in each case if enough trees are available. When possible tell what varieties of trees were sprayed.

Carefully note the date of spraying and observe the trees for at least three weeks. Also note whether the leaves fall from these trees earlier in the fall than from similar trees that were not sprayed. Keep a record of the weather conditions during the experiment.

Always use the whole of the 1-ounce sample forwarded to you with the required amount of water. This precaution is of the greatest importance, because of the fact that these 1-ounce samples are prepared from Paris Green to which is added definite amounts of pure arsenious oxid in order to obtain the various percentages of this substance. These are mixed as thoroughly as possible, but such mixing can never be perfect. Therefore, if only a part of the sample were used a higher or lower percentage of arsenious oxid might be present in that part than in the whole sample.

REPORT FROM THE MARYLAND STATION, COLLEGE PARK.

By B. H. Smith, T. B. Symons, and J. K. Haywood.

Forty-eight trees were utilized for this experiment, two for each of the solutions tested, one with and one without the addition of lime. The apple trees were York Imperials; the pears, Keiffers; the plums, American, and the peaches, Elberta and Mountain Rose. They were all in good condition and from 5 to 10 years old.

The following table gives a description of the weather conditions during the experiment:

Meteorological conditions at College Park, Md.

Date.	Precipitation.	General character of the day.	Date.	Precipitation.	General character of the day.
1902.	*Inches.*		1902.	*Inches.*	
May 11	0.00	Partly cloudy.	May 26	0.00	Partly cloudy.
12	.00	Clear.	27	1.53	Do.
13	.00	Do.	28	Trace.	Do.
14	.00	Do.	29	.00	Do.
15	.00	Do.	30	.81	Do.
16	.00	Do.	31		
17	.00	Do.	June 1	.00	Do.
18	.00	Do.	2	.00	Clear.
19	.00	Do.	3	.00	Do.
20	.00	Do.	4	.00	Do.
21	.00	Do.	5	.00	Partly cloudy.
22	.00	Partly cloudy.	6	1.07	Do.
23	.36	Do.	7		
24			8	.00	Do.
25	.00	Do.	9	.00	Do.

OBSERVATIONS.

The spraying was done on May 11, 1903, and the first observation was made on May 18, no rain having fallen in the meantime. No injurious effect from the sprays could be discovered on any of the trees. The orchard was examined a second time on May 26, a light rain having fallen on May 24. Among the apple trees a small percentage of the leaves of Nos. 4, 5, and 6 (6, 7, and 8 per cent of arsenious oxid, without lime) were very slightly burned, while No. 5 (7 per cent of arsenious oxid, with lime) had an occasional blackened leaf. The remainder showed no injury.

A number of the pear trees were affected with leaf spot (*Septoria pyricola*) and the pear leaf blister mite (*Phytoptus pyricola*) so that a great many leaves were beginning to blacken and wither.

A small part of the foliage of all the peach trees used in the experiment had begun to turn yellow and an occasional leaf showed black spots, but the general effect at this time was so slight that no appreciable difference could be said to exist between the several trees.

The plum trees showed no injurious effect from the spraying, with the exception of No. 5 (7 per cent of arsenious oxid, without lime), on which a few leaves were spotted.

On June 9, after three more rains, the apple trees had undergone practically no change since the first observation.

On the pears the disease and mite before mentioned were working havoc, and as the injury was as great on the trees sprayed with the weaker as with the stronger solutions and several trees not sprayed at all were affected to nearly as great an extent as those sprayed, it was thought best to exclude the pear trees from the experiment.

The peaches were now considerably damaged, though how much of this was due to the rather dry weather of the previous month, which doubtless had a certain amount of influence, was difficult to determine. The notes taken at this time are given below:

PEACHES (WITHOUT LIME).

No. 1. A few leaves have black spots; about 35 per cent turning yellow and dropping.

No. 2. Same.

No. 3. About 5 per cent of leaves more or less scorched; half the leaves dropping.

No. 4. Same.

No. 5. About 10 per cent of the leaves are scorched; leaves are yellow and as many on the ground as on the trees.

No. 6. Not burned as badly as the others and fewer leaves dropping; a very vigorous tree.

PEACHES (WITH LIME).

No. 1. No leaves burned; about 5 per cent dropping.

No. 2. Same, except that about 10 per cent are dropping.

No. 3. Very few leaves burned; leaves dropping considerably.

No. 4. Injury a little more pronounced than on No. 3.

No. 5. Practically the same as No. 4.

No. 6. About 5 per cent of leaves burned and dropping; almost the same as Nos. 4 and 5.

At this time the plum leaves were perforated to some extent by the plum leaf shot-hole fungus (*Septoria cerasina*), but also showed considerable injury from the spray. The notes made on this date are as follows:

PLUMS (WITHOUT LIME).

No. 1. Very few leaves burned.
2. Probably 5 per cent of leaves burned.
3. Same as No. 1.
4. Large percentage of leaves burned at edges.
5. Large percentage of leaves burned at edges.
6. Large percentage of leaves burned at edges.

PLUMS (WITH LIME).

No. 1. Few leaves slightly burned; small tree.
2. No injury.
3. No injury.
4. Few leaves burned.
5. Few leaves burned.
6. Few leaves burned.

After twenty days another examination was made. The intervening wet weather was evidently of great benefit to the orchard, as the trees had begun a new growth and the leaves, developed a darker color.

The slight injury to the apple trees of the month before was not noticeable, both those sprayed with and without lime being in good condition.

The peaches were located on a dry knoll and accordingly had suffered most from the drought, but at this observation, after having dropped their affected leaves and put forth new ones, both series of the trees had so far recuperated as to show scarcely any effect from the Paris Green, the foliage being nearly as thick as upon unsprayed trees.

The plum trees, while showing more injury than the peaches, were decidedly improved.

The last examination was made on August 8, and as far as could be ascertained the trees of all varieties had completely recovered from the effects of the various sprays.

CONCLUSIONS.

The effect of these Paris Greens, both with and without lime, upon the apple trees was very slight, and, as far as could be estimated, the same may be said of the pears.

To the peach trees considerable temporary injury, as shown by a dropping of the leaves, was done by all the greens without lime, although the trees seemed to recover later in the season. With lime the peaches were not injured to any great extent, even temporarily, by greens Nos. 1, 2, and 3 (2.84, 4, and 5 per cent of arsenious oxid), but were injured temporarily to quite an extent by greens Nos. 4, 5, and 6 (6, 7, and 8 per cent of arsenious oxid). All of the trees, however, seemed to recover before the end of the season. An interesting point noted in the case of the peach trees was that no injury was noticeable until a month after the application of the spray, the delay in action being probably due to the absence of rain.

Another fact emphasized by the observations was that the injury always depended to a considerable extent upon the physical condition of the individual tree; in a number of cases a particularly vigorous specimen showing no injury, while its less thrifty neighbor, which was perhaps sprayed with a Paris Green containing less soluble arsenious oxid, was seriously damaged.

From the results of this work it is believed that apple and probably pear trees can be sprayed with Paris Green containing 8 per cent of soluble arsenious oxid and sustain no injury. The observations made on peach and plum trees tend to show that if lime is added Paris Green containing as high as 5 per cent of free arsenious oxid may be safely used.

REPORT FROM THE NEW YORK STATION, ITHACA.

By John Craig and H. E. Weed.

The Paris Green was applied to the foliage of apple, pear, peach, and plum trees according to the directions accompanying the samples. The trees were sprayed on May 25, and 26, 1903, and the final results observed and notes taken on June 16. In the notes on the damage done to the foliage given below the terms "no injury indicated," "injury indicated," "somewhat injured," "injured," and "badly injured" are used to indicate the various degrees of injury in order that the results may be compared. In the same way the terms "spraying safe," "spraying questionable," and "spraying unsafe" are employed to indicate whether or not it would be expedient to spray with the amount of soluble arsenious oxid contained in the solution.

The rainfall during the period of the experiment and the results obtained are as follows:

Rainfall at Ithaca, N. Y.

Date.	Precipitation.	Date.	Precipitation.	Date.	Precipitation.	Date.	Precipitation.
1903.	*Inches.*	1903.	*Inches.*	1903.	*Inches.*	1903.	*Inches.*
May 1	T.	May 15	.00	May 29	.01	June 12	1.66
2	0	16	.00	30	.00	13	.01
3	.08	17	.00	31	.00	14	.01
4	.13	18	.00	June 1	.00	15	.11
5	0	19	T.	2	.00	16	T.
6	0	20	.00	3	.00	17	.19
7	T.	21	.02	4	.00	18	.28
8	0	22	T.	5	.00	19	.09
9	0	23	.00	6	.00	20	1.06
10	0	24	T.	7	.03	21	.74
11	0	25	.00	8	.01	22	0
12	0	26	T.	9	.05	23	.51
13	0	27	T.	10	.02		
14	0	28	.06	11	.04		

OBSERVATIONS.

APPLE, VARIETY GOLDEN SWEET.

No.	Mixture used.	Effect on foliage.	Remarks.
1	Without lime	Injury indicated	Spraying safe.
	With lime	No injury indicated	Do.
2	Without lime	Injury indicated	Do.
	With lime	No injury indicated	Do.
3	Without lime	Somewhat injured	Spraying questionable
	With lime	Injury indicated	Spraying safe.
4	Without lime	Injured	Spraying unsafe.
	With lime	Slight injury	Spraying safe.
5	Without lime	Injured	Spraying unsafe.
	With lime	Somewhat injured	Spraying questionable.
6	Without lime	Badly injured	Spraying unsafe.
	With lime	Injured	Do.

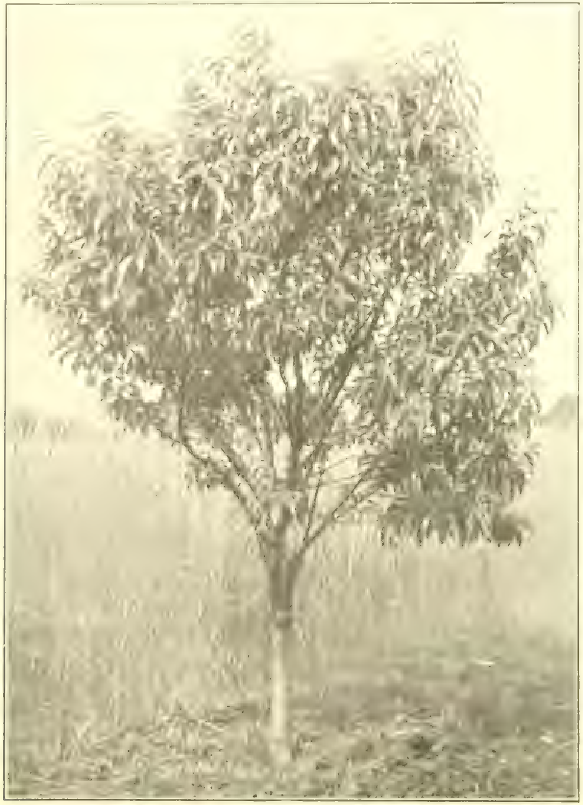

FIG. 1.—PEACH TREE WITH FOLIAGE IN NORMAL CONDITION.

Kingston, R. I., June 18, 1903.

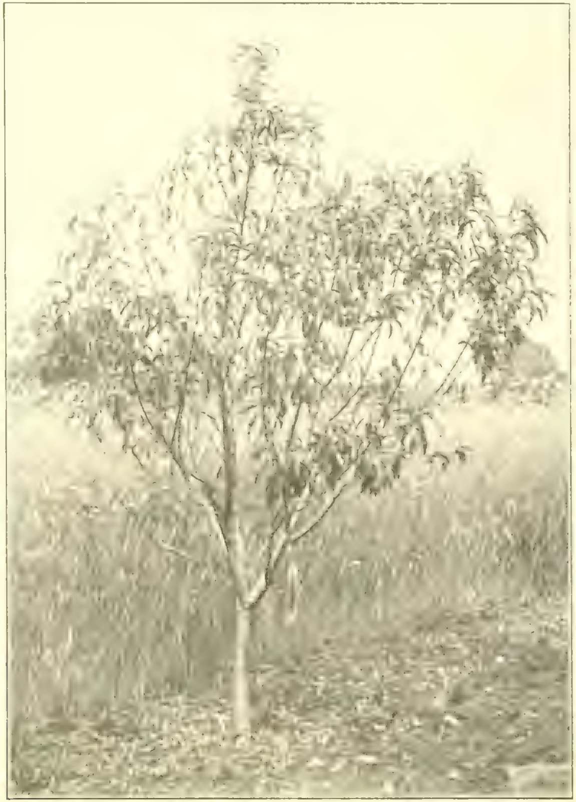

FIG. 2.—PEACH TREE SPRAYED WITH SOLUTION NO. 1, WITHOUT LIME.

Kingston, R. I., June 18, 1903.

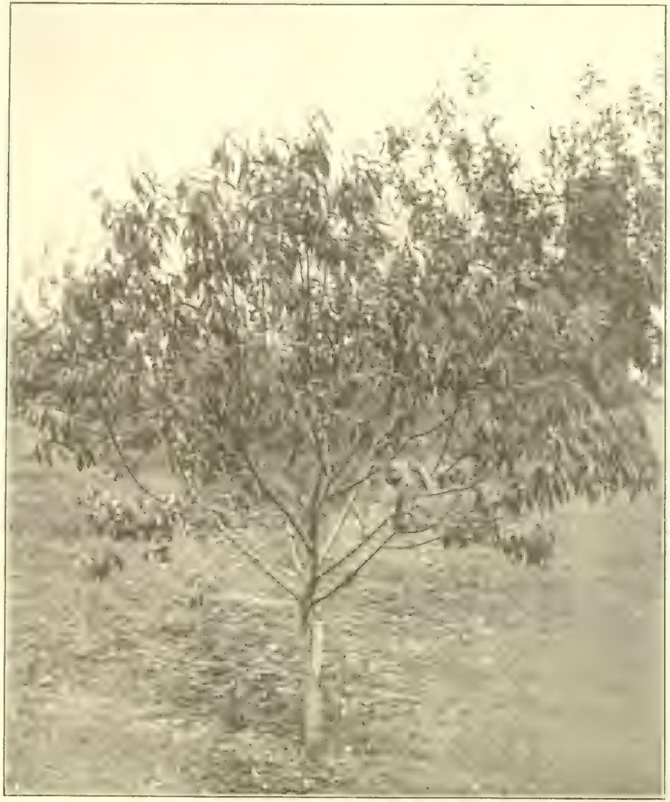

FIG. 1.—PEACH TREE SPRAYED WITH SOLUTION NO. 6, WITH LIME.

Kingston, R. I., June 18, 1903.

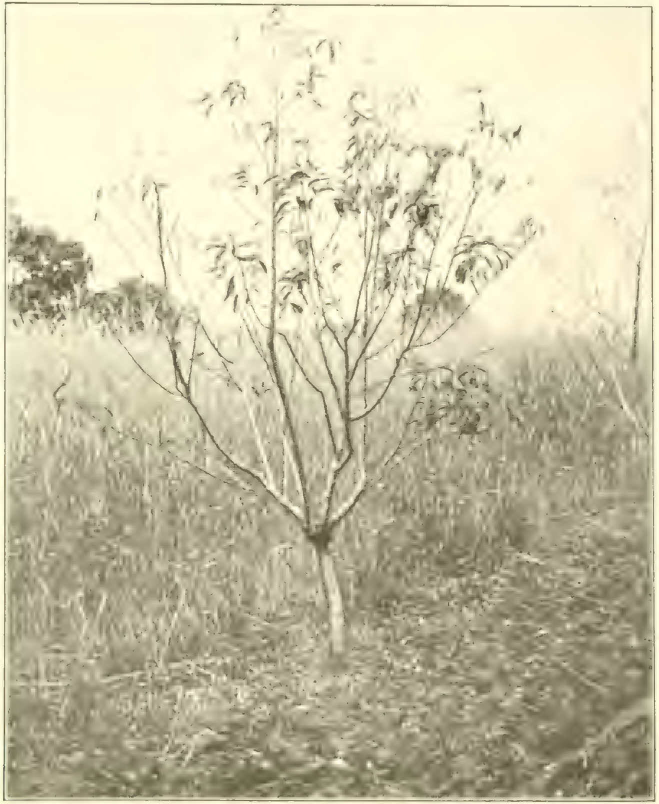

FIG. 2.—PEACH TREE SPRAYED WITH SOLUTION NO. 6, WITHOUT LIME.

Kingston, R. I., June 12, 1903.

Observations—Continued.

PEAR, VARIETY BARTLETT.

No.	Mixture used.	Effect on foliage.	Remarks.
1	Without lime	Injury indicated	Spraying safe.
	With lime	No injury indicated	Do.
2	Without lime	Somewhat injured	Spraying questionable.
	With lime	Injury indicated	Spraying safe.
3	Without lime	Injured	Spraying unsafe.
	With lime	Injury indicated	Spraying safe.
4	Without lime	Injured	Spraying unsafe.
	With lime	Somewhat injured	Spraying questionable.
5	Without lime	Badly injured	Spraying unsafe.
	With lime	Injured	Do.
6	Without lime	Badly injured	Do.
	With lime	Injured	Do.

PLUM, VARIETY MARIANNA.

No.	Mixture used.	Effect on foliage.	Remarks.
1	Without lime	Injury indicated	Spraying safe.
	With lime	No injury indicated	Do.
2	Without lime	Injured	Spraying questionable.
	With lime	Injury indicated	Spraying safe.
3	Without lime	Injured	Spraying unsafe.
	With lime	Injury indicated	Spraying safe.
4	Without lime	Badly injured	Spraying unsafe.
	With lime	Somewhat injured	Spraying questionable.
5	Without lime	Badly injured	Spraying unsafe.
	With lime	Injured	Do.
6	Without lime	Badly injured	Do.
	With lime	Injured	Do.

PEACH, VARIETY, STUMP.

No.	Mixture used.	Effect on foliage.	Remarks.
1	Without lime	Somewhat injured	Spraying questionable.
	With lime	Injury indicated	Spraying safe.
2	Without lime	Injured	Spraying unsafe.
	With lime	Injury indicated	Spraying safe.
3	Without lime	Injured	Spraying unsafe.
	With lime	Somewhat injured	Spraying questionable.
4	Without lime	Badly injured	Spraying unsafe.
	With lime	Injured	Do.
5	Without lime	Badly injured	Do.
	With lime	Injured	Do.
6	Without lime	Badly injured	Do.
	With lime	Injured	Do.

On June 16 and 17 another set of sprayings was made on the plum trees, the object being to obtain the cumulative effect of the sprays and also to ascertain whether the same injury would be done at this time as was noted after the sprayings of May 25 and 26. In this experiment the plum trees previously used were again sprayed with the same solutions and, in addition, some trees not used before were treated. Solutions Nos. 1, 2, and 3 were applied on the afternoon of June 16, and solutions Nos. 4, 5, and 6 on June 17. A rainfall of 0.19 inch occurred, however, on the same day, and the results with Nos. 4, 5, and 6 were entirely inconclusive, as no effect at all was produced, except on protected portions of the lower leaves.

The results obtained with Nos. 1, 2, and 3, applied on June 16 and followed by 0.19 inch of rain on the following day, while not definite enough for tabulation, plainly indicate that the last spraying did more injury than the first, and this was especially noted in the case of the trees which received two applications. The greater amount of injury resulting from the second spraying can be easily explained, as at the time of the first spraying the leaves were still young and the weather for four weeks previous had been extremely dry. Furthermore, from the weather chart it will be seen that only a small amount of rain fell during the three weeks following the spraying on May 25 and 26.

CONCLUSIONS.

The results obtained may be summarized as follows:

(1) Of the apple, pear, plum, and peach foliages the apple is injured the least, the pear and plum are affected to about the same degree, and the peach is injured the most.

(2) If only one application is made, Paris Green containing 4 per cent of free arsenious oxid can be applied with safety to apple trees and with the addition of lime 6 per cent may be present.

(3) If only one application is made to pear or plum trees, Paris Green containing 3 per cent of free arsenious oxid can be applied with safety and with the addition of lime 5 per cent.

(4) One application to peach trees of Paris Green containing 3 per cent of free arsenious oxid can not be made with safety without the addition of lime; with lime 4 per cent may be used.

(5) Two applications will do more damage than a single one, and more injury is apt to occur if the weather conditions were normal previous to the spraying than if very dry weather obtained.

Some observations were made on the manner in which the foliage of the different trees is affected. On the apple tree the injury is indicated by small, light-brown spots, well distributed over the leaves. On the pear and plum trees the damage is indicated by larger darkbrown spots, occurring mostly along the sides of the leaves, while on the peach leaves the spots are large, nearly circular, and distributed over various portions of the leaves.

REPORT FROM THE RHODE ISLAND STATION, KINGSTON.

By F. W. Card and A. E. Stene.

The spraying mixtures were made up strictly according to directions. The apple and pear trees were sprayed on May 25, 1903, and the peaches on May 27. The following table shows the weather conditions under which the experiment was conducted:

Meteorological data, Kingston, R. I.

Date.	Rainfall.	Character of day.	Date.	Rainfall.	Character of day.
1903.	*Inches.*		1903.	*Inches.*	
May 25	0.00	Clear.	June 5	0.00	Smoky.
26	.00	Do.	6	.00	Do.
27	.00	Partly cloudy.	7	.41	Cloudy.
28	.00	Cloudy.	8	.86	Do.
29	.00	Clear.	9	.00	Do.
30	.50	Partly cloudy.	10	.39	Do.
31	.00	Clear.	11	1.77	Do.
June 1	.00	Do.	12	.45	Do.
2	.00	Do.	13	.00	Clear.
3	.00	Do.	14	.00	Do.
4	.00	Smoky.			

OBSERVATIONS.

Apples.

The apple trees used for the experiment were Northern Spys, and one tree was sprayed with each sample of green. The trees stood in two rows, side by side, and the samples with lime were applied to one row and those without lime to the other. These experiments gave but slight results. Of the trees sprayed without lime the two receiving samples Nos. 2 and 5 (4 and 7 per cent of arsenious oxid) showed some burning of the foliage after the rains of June 7 to 10. The tree sprayed with No. 2 seemed to be the most affected. The trees sprayed with the addition of lime suffered no appreciable burning of the foliage.

Pears.

The pear trees receiving no lime were the Frederick Clapp, Hardy, Kieffer, Pitmaston Duchess, Supertine, and Anjou; those receiving the addition of lime were the Hardy, Hoosic, Louise Bonne, Sheldon, and

Urbaniste. These trees were all in a single row and every other one was sprayed with the samples containing no lime, the alternates being sprayed with the admixture of lime. After the rain of June 7 to 10 the Pitmaston Duchess, sprayed without the addition of lime, had a few burned leaves, and the Kieffer and Hardy, similarly treated, showed slight traces of burning. The trees receiving the spraying mixture mixed with lime showed no trace of burning whatever.

Peaches.

The peaches sprayed stood in two rows, side by side, one row receiving the Paris Green alone and the corresponding trees in the other row receiving the same green with the addition of lime. Those receiving the samples with lime were three of the Crawford Late variety and three Fitzgeralds. Three Champions and three of the Hill Chili variety were sprayed with the samples without lime. None of the trees showed any effects of the spraying until after the rain of May 30. The results in every case were proportionate to the amount of soluble arsenious oxid used. Those receiving the lime were far less affected than those not receiving it; in fact, the former showed hardly any effects until after the heavy rains of June 7 to 10. The tree which was sprayed with sample No. 6 (8 per cent of arsenious oxid), without lime, lost nearly all of its leaves and did not recover during the season. A number of the branches died and it made practically no growth after the application of the green. The tree sprayed with the same sample with lime was affected about the same as the tree sprayed with sample No. 1 (2.84 per cent of arsenious oxid) without lime. As before stated, the other trees were affected proportionately to the amount of soluble arsenious oxid in the sample with which they were sprayed.

It appears that sample No. 3 (5 per cent of arsenious oxid) represents the maximum limit when lime is added, since Nos. 4, 5, and 6 (6, 7, and 8 per cent of arsenious oxid) caused considerable damage. All of the greens did too much injury to the peach trees when used without lime. In no case did the trees sprayed seem to lose their leaves any earlier than those not sprayed.

The illustrations accompanying this report show the injury to peach trees inflicted by several of the greens, and with their legends explain themselves.

REPORT FROM THE SOUTH CAROLINA STATION, CLEMSON COLLEGE.

By C. E. Chambliss.

The solutions were made up and applied in strict conformity to the accompanying directions. The table following shows the condition of the weather during the time of the experiment.

Meteorological data, Clemson College, S. C.

Date.	Rainfall.	Maximum temperature.	Minimum temperature.	Date.	Rainfall.	Maximum temperature.	Minimum temperature.
1903.	*Inches.*	°*F.*	°*F.*	1903.	*Inches.*	°*F.*	°*F.*
June 12	00	75	58	June 22	T.	89	69
13	00	74	42	23	00	92	61
14	00	80	47	24	00	89	56
15	00	89	54	25	.08	90	60
16	00	89	54	26	.09	80	60
17	00	88	56	27	.10	80	66
18	00	91	58	28	00	85	62
19	00	91	60	29	00	87	66
20	00	94	62	30	00	93	62
21	00	....	....				

OBSERVATIONS.

APPLES (WITHOUT LIME).

This group of trees was sprayed on June 15, 1903, and observations were made on June 23, up to which time no rain had fallen, and again on July 11, during which period there had been several rainfalls. At the first observation no effects were noticeable on any of the trees. At the second observation the following effects were noted:

No. 1. Simmons Red.—The edges of some leaves were black and many had fallen.

No. 2. Maverick Sweet and Laurence Greening.—Foliage of the former was black on the edges, but no leaves had fallen. About one-fifth of the foliage of the latter was black on the edges, but no leaves had fallen.

No. 3. Laurence Greening and Elgin Pippin.—The foliage of the former was badly burned and one-third of it had fallen; one-third of the foliage of the latter was burned very slightly.

No. 4. Mrs. Bryan and Shockley.—The foliage of the former was only slightly burned and a few leaves had fallen; the foliage of the latter was burned and the tree seemed to be sickly.

No. 5. Yopps Favorite and Golden Beauty.—One-half of the foliage of both had fallen and the rest was badly burned.

No. 6. Horn.—One tree suffered a slight burning of the foliage, while the other was practically unaffected.

APPLES (WITH LIME).

This group of trees was sprayed on June 16, 1903, and observations were made on the dates mentioned above. At the first observation no effect was noticeable, but at the second the following changes were noted:

No. 1. Black Warrior.—One-half of the foliage had fallen and the remainder was slightly burned.

No. 2. Rawls Janet.—Only a few leaves had fallen, the remainder being slightly burned.

No. 3. Grimes Golden.—These two trees were apparently not affected.

No. 4. Family and Rhodes Orange.—A few leaves had fallen.

No. 5. Red June.—One-third of the foliage had fallen and the remainder was burned.

No. 6. Jewetts Best and Chattahoochee.—One-fifth of the foliage of the former had fallen and the remainder was burned. The foliage of the latter was only slightly burned.

PEACHES (WITHOUT LIME).

These trees were sprayed and observations taken on the dates mentioned above for apples without lime.

No. 1. Tinley's October.—At the first observation a few leaves had fallen and at the second four-fifths of the foliage had fallen and the remaining leaves were badly burned.

No. 2. Tinley's October.—At the first observation a few leaves had fallen and at the second four-fifths of the foliage had fallen and the remaining leaves were badly burned, but new leaves were putting forth.

PEACHES (WITH LIME).

These trees were sprayed on June 16, 1903, and observations were taken on the dates mentioned above.

No. 1. Elberta and Stump the World.—At the first observation a few leaves had fallen from both. At the second observation the former had lost one-half of its foliage and the remainder was badly burned, while the latter had lost four-fifths of its foliage, the remainder being the terminals.

No. 2. Tinley's October.—At the first observation a few leaves had fallen. At the second observation four-fifths of the foliage had fallen, but new leaves were putting forth.

The stronger spraying solutions, Nos. 3 to 6, were not tested on the peach trees.

PLUMS (WITHOUT LIME).

The trees were sprayed on June 15, and observations taken on the dates mentioned above.

No. 3. Lombard.—At the first observation a few leaves were slightly burned. At the second observation one-third of the foliage had fallen. The leaves were badly burned on one tree and very yellow on the other. New leaves were putting forth.

No. 4. Chalco.—At the first observation the leaves fell readily when the tree was shaken. At the second observation only a few leaves remained on the trees.

No. 5. Ogon and Wanamaker. At the first observation yellow leaves were numerous and fell readily when the trees were shaken. At the second observation all of the leaves had fallen.

No. 6. German Prune and Juicy.—At the first observation no effect was noticeable. At the second both were badly burned, but practically no leaves had fallen.

PLUMS (WITHOUT LIME).

The trees were sprayed on June 16, 1903, and observations taken on the dates mentioned above.

No. 3. Shiro and Fellenburg.—At the first observation no effect was noticeable. At the second some of the foliage of the former had fallen and yellow and badly burned leaves were present. Only a few leaves of the latter tree had fallen, but they were badly burned.

No. 4. Red June.—At the first observation leaves fell when the tree was shaken. At the second nine-tenths of the foliage had fallen and the remaining leaves were badly burned.

No. 5. Wickson and Abundance.—At the first observation the leaves of the former tree fell readily when shaken, and burned leaves were numerous on the latter. At the second observation one-half of the foliage of both had fallen, but new leaves were putting forth.

No. 6. Wickson and Sultan.—At the first observation leaves fell when the trees were shaken. At the second one-third of the foliage had fallen, but new leaves were putting forth.

RESULTS.

These results, obtained as they were by one spraying of one or two trees by each sample, are not considered conclusive; a tabulation of the results of several sprayings would be more significant. However, from the results obtained it would appear that it is not safe to spray apple trees with Paris Green containing more than 4 per cent of soluble arsenious oxid without lime; with lime not more than 6 per cent should be present. None of the samples, either with or without lime, appears to be safe on peach foliage. The smallest percentage used on plum trees was 5 per cent of soluble arsenious oxid, and that was too strong without lime, but from the results obtained with 5 per cent of soluble arsenious oxid with lime, it would seem that 4 per cent with lime would be safe.

REPORT FROM THE NEW HAMPSHIRE STATION, DURHAM.

By C. M. Weed and J. L. Randall.

Plum and apple trees were used for this experiment, as they were the only ones available for the purpose at the time. All the trees were of thrifty growth, the apples of five years bearing and the plums of two years. They were all of the same age and practically the same height. The trees were sprayed on July 28, which was warm and clear, and the effect on the foliage, whenever there was any, was noted within less than twenty-four hours. The following notes were taken:

OBSERVATIONS.

Apples (without lime).

Baldwin apples were used exclusively both for the experiments with and without lime.

No. 1 showed several burnt spots, but was not severely injured and no leaves fell.

No. 2 did not differ from No. 1 and the spots were not very abundant.

No. 3, although there seemed to be no cause for it, was burned more than any other tree except No. 6. Brown blotches appeared on a large part of the foliage and a few leaves curled as if about to fall.

Nos. 4 and 5 both had many burned spots and some blotches. None of the leaves curled, except occasionally when a blotch or spot came to the edge of the leaf.

No. 6 was injured the most of any. Large patches appeared on many of the leaves, which turned brown. Under the microscope the cell protoplasm was shrunken in these blotches and in the centers of the smaller spots.

APPLES (WITH LIME).

No. 1 had small brown spots on a very few leaves.

No. 2 was burned more than No. 1, yet the leaves did not fall and the cells were killed only in a few places.

No. 3 suffered little, if any, more injury than No. 2.

Nos. 4 and 5 showed some burned spots on the leaves unevenly distributed. These trees were affected about the same as Nos. 1 and 2 without lime.

No. 6 showed smaller but more numerous spots than those observed on Nos. 4 and 5.

PLUMS (WITHOUT LIME).

No. 1. Imperial Sage.—The leaves showed quite prominent brown spots, which were more numerous in the direct sunlight than on shaded parts of the tree.

No. 2. Bradshaw.—This tree was slightly more damaged than No. 1, but none of the leaves was injured enough to fall.

No. 3. Abundance.—This tree was damaged more than any other except No. 6. Many of the leaves were curled and a few fell. The tree had not entirely recovered when the leaves fell in the autumn.

No. 4. Washington.—Some of the leaves were burned and curled, but the injury done was not so great as in the case of No. 3. The tree had recovered before the leaves fell.

No. 5. Yellow Japan.—A few leaves curled and fell. This tree was burned more than No. 4 and about the same as No. 3.

No. 6. Wyant.—This tree was burned more than any other. Many of the leaves at the top were half burned and a large number fell.

PLUMS (WITH LIME).

No. 1. De Soto.—On July 30 this tree showed only a few scattered brown spots on the leaves. On August 15 it had entirely recovered.

No. 2. German Prune.—The injury was about the same as that inflicted on No. 1, without lime. A few brown spots were observed, which gradually disappeared, until on August 21 the tree had entirely recovered.

No. 3. Reine Claude.—About as much damage was done in this case as to No. 2, without lime, the lime seeming to nullify the effect of about 1 per cent of soluble arsenious oxid. On August 25 the tree had entirely recovered.

No. 4. Green Gage.—The leaves of this tree were burned in round spots, and a few curled; but in thirty days it had entirely recovered.

No. 5. Satsuma.—This tree was damaged about the same as No. 4, without lime.

No. 6. Weaver.—Spots and blotches appeared, and a few leaves fell; but the tree recovered before the season was over.

The authors of the report from the New Hampshire station prefer not to give an opinion in regard to the amount of soluble arsenious oxid that can be endured by apple and plum trees, as the data obtained is deemed by them insufficient to serve as a basis of such an opinion. It appears, however, to the author that certain tentative conclusions may be drawn which can be compared with the results obtained by the various other stations and definite conclusions thus be obtained. Basing, then, an opinion upon this single set of experiments, it would appear:

(1) That when lime is not used a Paris Green containing 4 per cent of soluble arsenious oxid can be used on apple trees, while one containing 7 per cent can be used with the addition of lime.

(2) That if lime is not used a Paris Green containing 4 per cent of soluble arsenious oxid can be used on plum trees. If lime is used it would appear that a Paris Green containing 5 or 6 per cent might be safely used.

REPORT FROM THE OREGON STATION, CORVALLIS.

By C. B. Cordley.

In the experimental work done in testing the effects of varying amounts of free arsenious oxid in Paris Green on foliage, the directions were very carefully followed. For each test the required amount of water was placed in a barrel, to which was added the amount of milk of lime specified, if any, and then the Paris Green. The whole was stirred thoroughly and at once sprayed upon the trees. The work was done with a small hand pump, fitted with a Vermorel nozzle, and great care was exercised to see that every leaf was thoroughly sprayed. In addition to the work outlined the effect of the stronger sprays (1 ounce to 9.5 gallons) on the foliage of a few delicate plants was tested.

The sprays without the addition of lime were applied on July 10, 1903. Evaporation was so rapid that the foliage was dry a few moments after being sprayed. On July 11 the conditions were similar, and samples Nos. 1 to 3, with 15.5 gallons of water and 2 ounces of lime, were applied. The remainder of the samples of that set, Nos. 4 to 6, with 15.5 gallons of water and 2 ounces of lime, and Nos. 1 to 6, with 9.5 gallons of water and 2 ounces of lime, were applied on July 17.

In the meantime, i. e., from July 10 to July 17, the weather had remained clear and bright. A critical examination, made on the latter date, of the trees sprayed on July 10 and 11 showed that none of them was injured.

On July 21 and 23 there were slight showers, and cloudy weather continued throughout the week. Thorough examinations were made on July 23, August 3, and December 1, the results of which are given in the tabular statements which follow. A table is also given showing the meteorological conditions which obtained for a number of days following the application of the sprays.

Meteorological conditions at Corvallis, Oreg.

Date.	Temperature.		Precipitation.	Character of day.	Date.	Temperature.		Precipitation.	Character of day.
	Max.	Min.				Max.	Min.		
1903.	*°F.*	*°F.*	*Inch.*		1903.	*°F.*	*°F.*	*Inch.*	
July 10	86	48	0.00	Clear.	July 21	70	50	0.04	Cloudy.
11	70	51	.00	Do.	22	72	47	.00	Do.
12	74	47	.00	Do.	23	66	52	.05	Do.
13	70	52	.00	Do.	24	74	59	.00	Do.
14	77	47	.00	Do.	25	75	47	.00	Partly cloudy.
15	86	48	.00	Do.	26	77	42	.00	Do.
16	81	50	.00	Do.	27	83	45	.00	Clear.
17	82	47	.00	Do.	28	84	45	.00	Do.
18	75	48	.00	Do.	29	77	54	.00	Partly cloudy.
19	81	50	.00	Do.	30	75	55	.00	Clear.
20	86	50	.00	Do.	31	77	46	.00	Do.

OBSERVATIONS.

TABLE I.—APPLES WITHOUT LIME.

[1 ounce to 9.5 gallons.]

Sample No.	Variety.	Injury.		
		July 23.	August 3.	December 1.
1	Mackintosh	None	None	But few leaves fallen.
	Carolina June	do	do	Do.
	Tuft's Baldwin	do	do	Do.
2	Benoni	do	do	Do.
	Crab	do	do	Completely defoliated.
	Spitzenberg	do	do	No leaves fallen.
3	do	do	do	Few leaves fallen.
	do	do	do	Do.
	Spokane Beauty	do	do	Do.
4	do	do	do	Do.
	do	Few leaves spotted	No increase of spots	Nearly defoliated.
5		None	None	Completely defoliated.
	Yellow Transparent	do	do	Half of leaves fallen.
	Grimes' Golden	do	do	Completely defoliated.
6	Hyde's King of West	Few leaves spotted	No increase of spots	Almost defoliated.
	Langford	Few leaves spotted and few killed.	No increase of injury.	Half of leaves fallen.
	Yakama	do	do	Few leaves fallen.
	Yellow Newton Pippin.	do	do	Completely defoliated.

Observations—Continued.

APPLES, WITH LIME.

Sample No.	Variety.	Injury. July 23.	Injury. August 3.	Injury. December 1.
1	Rome Beauty	None	None	But few leaves fallen.
	do	do	do	Do.
	do	do	do	Half of leaves fallen.
2	do	do	do	Completely defoliated.
	Waxen	do	do	But few leaves fallen.
	do	do	do	Nine-tenths of leaves fallen.
3	do	do	do	Do.
	do	do	do	Do.
4	do	do	do	Three-fourths of leaves fallen.
	do	do	do	Do.
	do	do	do	Seven-eighths of leaves fallen.
5	do	do	do	Few leaves fallen.
	do	do	do	Three-fourths of leaves fallen.
6	do	do	do	Seven-eighths of leaves fallen.
	do	Few leaves slightly spotted, and a few more killed.	No increase of injury.	Do.

TABLE II.—PEARS, WITHOUT LIME.

[1 ounce to 9.5 gallons.]

Sample No.	Variety.	Injury. July 23.	Injury. August 3.	Injury. December 1.
1	Directeur Alphando	None	None	Completely defoliated.
	Colonel Wilder	do	do	But few leaves fallen.
2		do	do	Completely defoliated.
3	Bartlett	do	do	Few leaves fallen.
4		do	do	Do.
	Patrick Barry	do	do	Do.
5	Winter Bartlett Fame	Leaves slightly injured about margins of holes eaten by slugs.	No increase of injury.	Completely defoliated.
6	Genesta	None	None	Do.

PEARS, WITH LIME.

Sample No.	Variety.	Injury. July 23.	Injury. August 3.	Injury. December 1.
1	Cockling	None	None	Tree dead from other causes.
3	Buffum	do	do	Completely defoliated.
	do	do	do	Do.
4	Lincoln	do	do	But few leaves fallen.
5	Genesta	do	do	Do.
6	do	do	do	Seven-eighths of leaves fallen.
	Assumption	do	do	Completely defoliated.

Observations—Continued.

TABLE III.—PLUMS,[a] WITHOUT LIME.[b]

[1 ounce to 9.5 gallons.]

Sample No.	Variety.	Injury.		
		July 23.	August 3.	December 1.
1		None	None	Completely defoliated.
3		....do	....do	Do.
		....do	....do	Do.
		....do	....do	Do.
4		....do	....do	Do.
		....do	....do	Do.
5		....do	....do	Do.
6	Herefordshire	....do	....do	No record.

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[a] These trees were all prune-bearing plum trees, and were reported under the former designation; but the term "plum" is here used to bring them into comparison with the other plum trees used in the experiment.

[b] For the report on plums sprayed with the addition of lime see text at close of tables, page 29.

TABLE IV.—PEACHES, WITHOUT LIME.

[1 ounce to 15.5 gallons.]

Sample No.	Variety.	Injury.		
		July 23.	August 3.	December 1.
1	Old Mixon	None	None	Three-fourths of leaves fallen.
2	....do	Slightly injured	No increase of injury.	One-fourth of leaves fallen.
3	....do	....do	....do	One-half of leaves fallen.
4	....do	Considerably spotted.	One-fourth of leaves fallen; the rest injured.	Do.
5	Mont Rose	....do	....do	Do.
6	....do	Badly injured	One-half of leaves fallen; the rest injured.	
	....do	....do	....do	Do.

PEACHES, WITH LIME.

Sample No.	Variety.	July 23.	August 3.	December 1.
1	Lewis's Seedling	None	None	Three-fourths of leaves fallen.
	Imperial	Badly injured	One-half of leaves fallen.	One-fourth of leaves fallen.
2	....do	Slightly injured	No increase of injury.	Do.
	....do	....do	....do	Do.
3	Mumé	Very slightly injured.	....do	Do.
	....do	....do	....do	Do.
4	Alexander	None	None	Seven-eighths of leaves fallen.
		....do	....do	Three-fourths of leaves fallen.
5		....do	....do	Do.
	Willett	....do	....do	Do.
6	Old Mixon	....do	....do	No record.

Observations—Continued.

TABLE V.—PLUMS, WITHOUT LIME.

[1 ounce to 15.5 gallons.]

Sample No.	Variety.	Injury.		
		July 23.	August 3.	December 1.
1	Imperial Epineuse	None	None	Almost entirely defoliated.
	do	do	do	Do.
2	do	do	do	Do.
	do	do	do	Do.
3	do	do	do	Do.
	Willamette	do	do	Do.
4	do	do	do	Do.
	do	do	do	Completely defoliated.
5	do	do	do	Almost entirely defoliated.
	do	do	do	Completely defoliated.
6	do	do	do	Do.
	Robe de Sargent	do	do	Do.

PLUMS (WITH LIME).

Only three trees were sprayed with the solutions made up with 9.5 gallons of water, Nos. 2, 3,[a] and 4 being used. No effects from the sprays were to be observed on either July 23 or August 3. On December 1 the first two were entirely defoliated, while the tree treated with No. 4 had only lost a few leaves.

A number of varieties were sprayed with the solutions Nos. 1 to 6, made up with 15.5 gallons of water to an ounce of the green. None of the trees showed any injury on either July 23 or August 3, but on December 1 all were either completely, or almost completely, defoliated. A Reine Claude plum tree sprayed with No. 1 and a Green Gage sprayed with No. 3 were among this group, with results as stated.

DISCUSSION.

The observations made on December 1 were for the purpose of finding out whether the sprayed trees dropped their leaves earlier in the fall than those not sprayed, and whether this premature falling, if it existed, had any relation to the amount of soluble arsenious oxid used on the tree. The time at which the leaves fall ordinarily varies greatly with the season and the variety of the tree. The college orchard consists of two or three trees each of quite a number of varieties, and when they were examined, on December 1, there was not only a surprising degree of variation in the condition of the foliage of the different varieties but also a great difference between the several trees of the same variety. Two apple trees (Waxen) standing side by side were sprayed with No. 2 plus lime. On December 1 only a few leaves had fallen from one of the trees while on the other not over 10 per cent remained. Likewise two trees of the same variety, standing side by side in the same row, were sprayed with No. 5 plus lime. When examined three-fourths of the leaves had fallen from one and only a few from the other. Thus the examination of the orchard failed to show that the spray had any effect whatever upon the falling of the foliage. The tabulated data, however, seem to indicate that a somewhat larger proportion of leaves had fallen by December 1 from trees sprayed with Nos. 5 and 6 than from those treated with Nos. 1, 2, 3, and 4. Whether this was due to the sprays or to mere chance in the selection of the trees, it is impossible to say. Little effect if any was produced on the apple, pear, and plum trees.

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[a] A cherry tree sprayed with No. 3 without the addition of lime showed no injury on July 23 and August 3, and on December 1 it was entirely defoliated.

As to the effects of the various strengths of soluble arsenious oxid the results of this set of experiments alone seem to show that under favorable conditions, such as prevailed at the time the spraying was done and during the following 30 days, it is safe to spray apple, pear, and plum trees with any of the 6 samples, both with and without the addition of lime. None of the samples injured any of the varieties of these fruits sufficiently for the damage to be considered of practical importance in orchard work. It may be noted, however, that the work was done under peculiarly favorable conditions. Probably not over 15 minutes elapsed in any case from the time the poison was first mixed in the water to the time it was sprayed on the trees, giving but a short time for the arsenious oxid to enter into solution, and the weather conditions were such that after being sprayed on the trees the moisture evaporated very rapidly. Under practical orchard conditions it would probably be safer not to use Nos. 5 and 6 on apple, plum, or pear trees without the addition of lime.

No conclusions can be drawn from this series of experiments as to the peach trees, as these trees in the college orchard are growing on soil entirely unsuited to them. The trees are not thrifty, some of them are nearly dead, and it is believed that the resistance of the foliage of the various trees to the action of the soluble arsenic varies greatly.

SUMMARY.

The following table shows the maximum amount of soluble arsenious oxid in Paris Green which can be safely used on the varieties of fruit trees included in these experiments. It must be remembered when 8 per cent is given as the maximum that this was the strongest solution used, and had stronger ones been employed they might have been found safe also for such trees as endured the 8 per cent solution of soluble arsenious oxid, and these cases are therefore marked "8 +." If even the smallest amount of soluble arsenious oxid was found to be injurious the word "inapplicable" is used, since the sample marked No. 1 is as pure a Paris Green as can be obtained on the market.

Amounts of soluble arsenious oxid allowable in Paris Green.

[Samples analyzed by ten-day water-extraction method.]

Place of experiment.	Apple.		Pear.		Peach.		Plum.	
	Without lime.	With lime.	Without lime.	With lime.	Without lime.	With lime.	Without lime.	With lime.
	Per cent.	*Per ct.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
Washington, D. C	8+	8+	8+	8+	Inapplicable.	6	....	....
College Park, Md	8+	8+	8+	8+	....do...	5	4	5
Ithaca, N. Y	4	6	3	5	....do...	4	3	5
Kingston, R. I	6	8+	8+	8+	....do...	5	....	....
Durham, N. H	4	7	....	....	....	....	4	5-6
Clemson College, S. C	4	6	....	....	Inapplicable.	Inapplicable.	....	4
Corvallis, Oreg	8+	8+	8+	8+	....	....	8+	8+

A study of the weather charts for the various stations shows that the following periods elapsed between the dates of spraying and the first rainfall: Washington, D. C., about 10 days; College Park, Md., about 12 days; Ithaca, N. Y., about 3 days before a very light rain and then 13 days before the next rainfall; Kingston, R. I., about 5 days and then 7 more before another rain; Clemson College, S. C., 10 days, followed by a very light rainfall and a long dry term. It is thus seen that in nearly all cases the weather conditions were almost ideal, if the word may so be used, for producing the maximum damage from the sprays. During the rather long dry period after spraying, when only light rains fell, if any, the dew and carbon dioxid of the air acted upon the Paris Greens, causing them to decompose and set free the arsenious oxid, so that when rain finally came a large amount of soluble arsenious oxid was present, which the leaves absorbed and thus caused burning. These conditions were especially striking at Clemson College, where no rain fell for 10 days, after which just about enough rain fell for 3 days to dissolve the soluble arsenious oxid and yet not wash it off. Another dry period followed, terminated by rains, which caused the soluble arsenious oxid to burn the foliage.

Taking the weather conditions into consideration, and judging the results in a very conservative manner, it would appear from the figures given in the table that the following conclusions may be drawn:

(1) For apple trees sprayed without the use of lime the amount of soluble arsenious oxid[a] allowable lies between 4 and 8+ per cent, a fair average being 6 per cent.

(2) For apple trees sprayed with the use of lime the amount of soluble arsenious oxid allowable is between 6 and 8+ per cent, a fair average being 7 per cent.

(3) For pear trees sprayed without the use of lime the amount of

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[a] By soluble arsenious oxid is meant the amount extracted from 1 part of Paris Green by 1,000 parts of carbon dioxid-free water during the course of 10 days.

soluble arsenious oxid allowable is between 3 and 8+ per cent, a fair average being 6 per cent.

(4) For pear trees sprayed with the use of lime the amount of soluble arsenious oxid allowable is between 5 and 8+ per cent, a fair average being 7 per cent.

(5) For plum trees sprayed without the use of lime the amount of soluble arsenious oxid allowable is between 3 and 8+ per cent, a fair average being about 4 per cent.

(6) For plum trees sprayed with the use of lime the amount of soluble arsenious oxid allowable is between 4 and 8+ per cent, a fair average being from 5 to 6 per cent.

(7) In spraying peach trees none of the Paris Greens bought upon our market should be used without the addition of lime.

(8) For peach trees sprayed with the use of lime the amount of soluble arsenious oxid allowable lies between 3 and 6 per cent, a fair average being 4.5 per cent.

(9) The difference in the effect produced by Paris Greens used with and without the addition of lime is so great that lime should always be employed.

For ready reference these conclusions are also embodied in the following table:

Maximum and average amounts of soluble arsenious oxid allowable.

Apple.				Pear.			
Without lime.		With lime.		Without lime.		With lime.	
Limits.	Average.	Limits.	Average.	Limits.	Average.	Limits.	Average.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4–8+	6	6–8+	7	3–8+	6	5–8+	7

Peach.				Plum.			
Without lime.		With lime.		Without lime.		With lime.	
Limits.	Average.	Limits.	Average.	Limits.	Average.	Limits.	Average.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0–0	0	3–6	4.5	3–8+	4	4–8+	6

It is evident that the amount of soluble arsenious oxid allowable in a Paris Green depends largely on the kind of fruit tree that is to be sprayed. The author is of the opinion that State chemists should not select any fixed standard by which to judge all Paris Greens sent in by the farmer, but should find out for what purpose the green is to be used and base his decision on the resisting power of the kind of tree to be sprayed. It would perhaps be advisable to have a printed form giving the names of the various common fruit trees and to state after each whether or not the sample sent could be used upon it.

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